

**Center for Computer Research
in Music and Acoustics**

**Department of Music
Stanford University**

John Chowning, Director

Progress Report September 1984 – August 1985

Introduction

The Stanford Center for Computer Research in Music and Acoustics (CCRMA) is an interdisciplinary facility where composers and researchers work together using the computer as a new musical and artistic medium, and as a research tool.

Areas of ongoing research and development at CCRMA include: Applications Hardware, Applications Software, Synthesis Techniques and Algorithms, Signal Processing, Digital Recording and Editing, Psychoacoustics and Musical Acoustics, Applied Artificial Intelligence, Music Manuscript by Computer, and Composition.

The following describes results of research accomplished during the year 1984–85. A summary of this work supported by the System Development Foundation will follow.

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- A new theory of digital reverberation has been developed by Julius Orion Smith III. The Stanford Office of Technology and Licensing has applied for a patent on this technology.
 - Development began on a new music editing system.
 - A distributed computing environment for music recognition and transcription work was completed. Xerox Lisp machines share processing tasks and access analog converters, signal processing, printers and synthesizers via CCRMA's local network.
 - Music recognition software has advanced to the stage of accomplishing polyphonic analyses. New methods employ feedback from context levels to assist signal processing tasks.
 - As part of our continuing research in the automatic recognition of musical structure, we have developed algorithms to identify musical patterns in a score, such as rhythmic patterns and pitch patterns. The method relies on an enumeration algorithm and a variety of criteria to measure the importance of patterns. In our automatic transcription system, the acoustic analysis subsystem identifies events, and the musical analysis subsystem interpret these events as musical notes on a score. Pattern detection is then used to evaluate redundancies and/or discrepancies in the analysis. This provides an extremely effective tool for providing feedback to the earlier stages of analysis, by specifically pointing to possible spurious events, missed events or mislabeled events.
 - Work on the synthesis of percussive sounds with substantial data reduction, scored digitally recorded sounds which can be manipulated and recombined to create new sound entities, implementation of the CHANT synthesis program developed at IRCAM continued.

- Work in setting up a portable Signal processing library began.
- New research in the area of real-time performed digital synthesis and processing was begun. Recent acceptance by the music industry of communication standards and protocols (MIDI) suggest new and novel application and research areas in music research and composition. This work was begun by John Chowning while on sabbatical at IRCAM, Paris and will continue at CCRMA.
- New research explored the problem of finding suitable control structures for synthesis from physical models of stringed instruments. The computer programs simulate motion of a string when plucked or bowed.
- Work in time domain speech analysis and recognition using novel techniques of segmentation and pitch detection; newly developed techniques for adaptive signal processing; and extension of the phase vocoder analysis to the complete musical phrase continued.
- New developments in signal processing included a phase vocoder capable of analyzing and synthesizing inharmonic spectra such as the piano, several techniques for synthesizing interpolations between two timbres, and an implementation of the Wigner transform.
- A simple but general formalism for specifying complex ensemble relationships was devised and implemented on the Xerox 1108.
- Work was completed in using the Samson Box synthesizer as a "sampling device" in musical compositions. Unlike commercial products of this type, fully independent control of frequency and amplitude is possible. Software creates continuous, multi-note phrasing and automatically splices sampled sources onto purely synthetic material.
- Music printing by computer continues to be used by faculty and students of the Department of Music and by the Library of Congress' special library for the handicapped. The latter requires high quality large print music for the visually impaired. New work in this area included the development of an operational vertical justifying program for music printing. This program will take an orchestral score with c.64 staves and create the optimal vertical spacing for any page height given. The program gives a graphical representation of the "skyline" contour of each line of music. Possible vertical overlaps are detected and staff position is adjusted as necessary. A program was developed to convert any font to vector outlines for later rescaling.
- Work was begun on a music printing program for the Tandy 2000 personal computer. A complete graphics system which is callable from any standard MS-DOS language was written. (High-speed line drawing, overlays, programmable graphics cursor, selective graphics editing, fill nested polygons, zooming and scaling.) A comprehensive drawing program to create musical symbol libraries for the music printing system was also developed.
- Dissertations completed under SDF support were "Modeling Musical Transitions" by John Strawn, and "On the Automatic Transcription of Percussive Music" by Walter A. Schloss. Research continued on a dissertation on the perception of pitch in children by Eduardo Castro-Sierra which makes use of an implementation of the Klatt synthesis algorithm and machine analysis.
- Specifications for the studios and workspaces at the CCRMA's new facility on the Stanford campus were completed. Construction is underway and CCRMA will occupy the facility in winter 1985.

Publications

Chafe, Chris. "Bowed String Synthesis and Its Control From a Physical Model." STAN-M-32, Stanford University, July 1985.

Chafe, Chris, Jaffe, Kashima, Mont-Reynaud, Smith. "Techniques for Note Identification in Polyphonic Music." Proceedings of the ICMC, 1985.

Gordon, J. and Smith, J.O. "A Sine Generation Algorithm for VLSI Applications." Proceedings of the ICMC, 1985.

Jaffe, D. "Ensemble Interaction in Computer Music." STAN-M-23, Stanford University, October 1984. Also to be published in the *Computer Music Journal*, MIT Press.

Malouf, F. "A System for Interactive Music Composition through Computer Graphics." Proceedings of the ICMC, 1985.

Mont-Reynaud B. and Goldstein, M. "On Finding Rhythmic Patterns in Musical Lines." Proceedings of the ICMC, 1985.

Pierce, John R. *The Science of Musical Sound*. Scientific American Books, W. H. Freeman and Company, San Francisco, 1983. Cassette of sound examples and pieces to accompany the book. 1985.

Roads, C. "John Chowning on Composition." In C. Roads, Ed. *Composers and the Computer*. Los Altos, California: William Kaufmann, Inc., 1985.

Schloss, W. "On the Automatic Transcription of Percussive Music." Ph.D. thesis, Department of Speech and Hearing, Stanford University, Stanford, California. 1985.

Smith, J. O. "A New Approach to Digital Reverberation Using Waveguide Networks" Proceedings of the ICMC, 1985.

Smith, J. O. "Introduction to Digital Filter Theory." In J. Strawn, Ed. *Digital Audio Signal Processing: An Anthology*. Los Altos, California: William Kaufmann, Inc., 1985.

Strawn, John. "Orchestral Instruments: Analysis of Performed Transitions?" Proceedings of the ICMC, 1985.

Strawn, John. "Computers and Music." *The New Grove Dictionary of Music in the United States*. New York: Macmillan, in press.

Strawn, John, Ed. *Digital Audio Engineering: An Anthology*. Los Altos, California: William Kaufmann, Inc., 1985.

Strawn, John, Ed. *Digital Audio Signal Processing: An Anthology*. Los Altos, California: William Kaufmann, Inc., 1985.

Visiting Composers and Scholars 1984-85

Visiting composers and researchers at CCRMA during 1984 and 1985 included:

Jonathan Berger	composer and assistant professor of music, Yale University (summer 1985)
Jean-Pierre Dautricourt	composer and physicist from France (one year beginning Sept. 1984)
Fred Malouf	Rockefeller composer in residence (one year beginning Sept. 1984)
Michael McNabb	composer (NEA fellowship for one year)
Ira Mowitz	composer (one year beginning Sept. 1984)
Adolfo Nunez	composer from Spain (two years beginning Sept. 1984)
Brian Schober	Rockefeller composer in residence (one year beginning Sept. 1984)
Elzbieta Sikora	Polish composer from Warsaw, now living in France (Sept. 1984)
Vladimir Ussachevsky	composer and professor of music, University of Utah (summer 1984)

Other visitors to CCRMA included:

Curtiss Abbott, Lucasfilm
 Martin Bresnick, faculty, Yale University
 William Buxton, University of Toronto
 JoAnne Carey, graduate student, San Jose State
 Claude Cadoz, ACROE, Grenoble, France
 John Cage, composer
 Gayle Curtis, Veterans Administration Rehabilitation
 Giovanni Debiagi, University of Padua
 Mark Dolson, CME, UCSD
 Richard Felciano, composition faculty, UC Berkeley
 Esther R. Ferrington, Time/Life Books
 Scott Foster, Hewlett Packard
 Denman Gerstung, composer, Germany
 Stan Getz, musician
 Phil Gossett, Symmetry
 Robert Gross, IRCAM
 Micky Hart, musician
 David Haynes, IMS Inc.
 William Hewlett, CCRH
 Henkjan Honing, composer
 Hiro Kato, Yamaha, Japan
 Gary Kendall, Northwestern University
 Paul Kiparsky, CSLI
 Eric Lazarus, Intellicorp
 Mark Lieberman, Bell Laboratories
 Annie Luciani, ACROE, Grenoble, France

Dick Lyon, Schlumberger
Noriko Manabe, composer
Elliot Mazer, recording engineer
Carver Meade, Cal Tech
Dana Massey, EMU Systems
Mr. Mochida, Yamaha, Japan
Mr. Ohno, Yamaha, Japan
Pauline Oliveros, composer
Jozef Patowski
Michael S. Pettersen, Shure Bros.
David Rosenboom, Mills College
Hasmig Serophian, Apple Computer
Janet Small, composer
Bill Spencer, Xerox PARC
Heinrich Taube, composer
Hans Tschernig, Dynacord, Germany
Dan Timis, IRCAM
Raymond Torres-Santos, composer
Pieter Van der Linden, INRIA, France
Natalie Van Bockstaelle, UC Berkeley
Mr. Wachi, Yamaha, Japan
Brenda Way, ODC San Francisco
Chuck Weaver, SRI

Grants Received by CCRMA

System Development Foundation, "Computer Research in Music and Acoustics", September 1, 1982 for 5 years, \$2.3 million. (for operating support, equipment, and development of 68000-based computer music workstations).

NSF MCS-82-14350, "An Intelligent System for the Knowledge-Driven Analysis of Acoustic Signals", July 1, 1983 for 2 years, \$354,954. (research support)

Rockefeller Foundation, "Support for Visiting Composers", June 1984 for 1 year, \$30,000. To support two visiting composers at CCRMA. Brian Schober from New York and Fred Malouf from Indiana.

NEA A84-005025, "Music Recording Project: works from CCRMA", July 15, 1984 for 1 year, \$2,900.

NEA 42-3165-0526, "Centers for New Music Resources", June 1, 1984 for 1 year, \$5,800. (for audio equipment)